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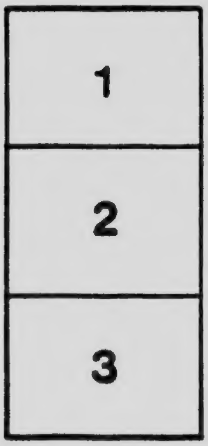
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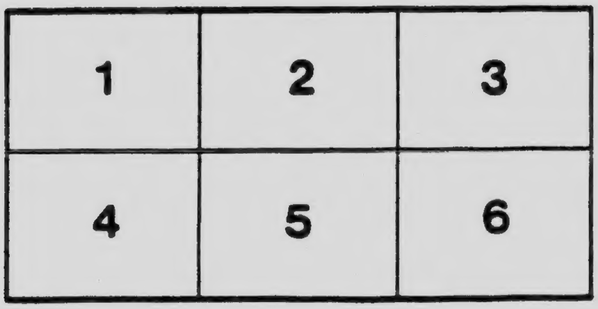
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GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, I.S.O., Sc.D. (Cantab.), M.D., LL.D., F.R.S.

PRELIMINARY REPORT

ON THE

ROSSLAND, B.C., MINING DISTRICT

BY

R. W. BROCK

OTTAWA
GOVERNMENT PRINTING BUREAU
1906

No. 939.

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No. 939.

DR. ROBERT BELL,
Acting Director,
Geological Survey of Canada.

DEAR SIR,—I beg to submit, herewith, a preliminary report on my investigations in the Rossland mining district of British Columbia.

A more complete report is being prepared, and will be handed in when the illustrations and maps are ready.

Your obedient servant,

R. W. BROCK.

OTTAWA, March, 1906.

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PRELIMINARY REPORT ON THE ROSSLAND MINING DISTRICT.

SUMMARY OF OPERATIONS.

After receiving instructions, in March, to undertake a detailed geological survey of the Rossland mining camp, I organized a party which was ready to take the field early in May. It was afterwards decided that as two seasons had been spent in the Lardeau district, it would be better to first complete a map of that region, and to devote the remainder of the season to Rossland. Thereupon the Rossland party was disbanded and when the final instructions were issued to proceed at once with the geological survey of Rossland, it was too late to secure either the men previously engaged or properly trained substitutes. Consequently, it was impossible to carry out the work as originally planned. On June 14 I left Ottawa for Rossland, accompanied by Dr. G. A. Young and Mr. W. H. Boyd of this Survey . Mr. Boyd took charge of the topographical work, with Messrs. S. King and G. Galt as assistants, while Dr. Young made a special study of the rocks and their areal distribution. My own attention was largely occupied in a study of the underground and economic geology of the camp. James Denny was engaged during the season in preparing thin sections of rocks and ores. During part of the season Dr. Young had a field assistant and, for a time, I was assisted in underground work by Mr. D. F. McEwen.

TOPOGRAPHICAL WORK.

The area embraced in the map sheet, as planned, extends from east of Columbia-Kootenay mountain westward to the west slope of Little Sheep Creek valley, embracing the summits of Monte Christo and Red mountains, and southward to the south slope of Trail creek, beyond the Canadian Pacific railway. It thus includes all the important mines, many of the claims that have attracted attention, and most of the extraordinarily numerous rock types of the district. Owing to the want of a detailed topographical map, little progress in areal geology could be made during this season, and this part of the work has for the most part been postponed until Mr. Boyd's results are available.

After establishing a base line in Rossland and erecting signals at suitable points, Mr. Boyd made a triangulation survey, giving a skeleton map of the area. Between the stations thus fixed, transit-stadia traverses, including those of railways, streets, roads, trails, &c., are run, and from stations on these traverses, subordinate traverses are made and points of topographical importance are fixed. A scale has been adopted large enough to show all surface improvements and the principal geological features. Contour lines at 20-foot intervals indicate the salient features of the topography. Every care is being exercised to insure accuracy, and the resulting map should prove of general use and value. Mr. Boyd also attended to

the construction of the map. The topographical work of the season includes the triangulation, surveying and mapping of the complicated area occupied by the town and principal mines. An accident to the transit, necessitating its return to the factory for repairs, occasioned some delay in the prosecution of the work.

GEOLOGICAL WORK.

The conclusions drawn from Dr. Young's work have been incorporated in the following pages.

The writer spent the first week in a general survey of the area included in the map sheet, and then commenced the underground work. As he was already somewhat familiar with the geology and ore deposits of the three larger mines, typical of the central and developed part of the camp, he commenced work on the outlying workings, in the hope of discovering differences of conditions that would throw some light on the causes of mineralization, and thus afford a clue that might be of service in prospecting for ore bodies in the district. Where plans existed of the mine workings, these were used; where none were procurable, surveys were made. On these plans the underground geological features were plotted. This necessitated tedious, detailed work, all the rock surfaces being dirt-covered. The following properties were examined:—White Bear, California, Spitzee, Gertrude, Mascot, Columbia-Kootenay, Giant, Novelty, Homestake, Monte Christo, Colonna, Jumbo, Cliff, St. Elmo, Le Roi No. 2 (partly); a few days were spent in the Le Roi, War Eagle and Centre Star.

As it is the intention to publish a separate pamphlet on the Rossland camp, only a few features need be mentioned in this summary of the season's operations. The geological problems presented in this camp are of extreme complexity; moreover, the unfavourable natural conditions render some of them, for the present at least, insolvable. The few stratified rocks have, through intense metamorphism, lost all original characteristics of texture and structure; the greater part of the district consists of igneous rocks of both surface and deep-seated origin. It is, in fact, a section through an old volcano or volcanoes, which were active for long periods and which have therefore the most complex anatomy. The rocks, though often closely related in composition and period of formation, are of infinite number and variety. Many varieties closely resemble one another, and are very difficult, in certain cases impossible, to distinguish by the naked eye; yet they may differ materially in age. The plutonic rocks, which have invaded the others, have altered their attitudes and obscured their original forms, while the plutonics themselves might have had any form, so that what their original outlines were, cannot be presaged. The rocks are traversed by, literally, thousands of dikes, too numerous or irregular to be of much use as keys to structure. The complexity of the whole is rendered more obscure by innumerable slips and faults. Moreover, the rocks

on the surface are frequently so weathered as to lose individuality, and the wide-spread mineralization has wrought profound changes in many of the rocks. The wash covers at least one-half the surface, so that in the absence of any key horizon, few geological features can be traced with certainty on the surface. With a diabolical perverseness, wash almost always overlies crucial points. The underground workings which, in some respects, escape the surface disadvantages, were certainly not located with the idea of elucidating the geological problems. Moreover, they are to a considerable extent in altered or mineralized rock. All these factors tend to make the study of the camp a disheartening undertaking. There are, however, two questions of the utmost economic importance, and so long as there is any possibility of the present work contributing at all towards their solution, it is well worth pursuing. These questions are, first, do the ore-bodies now being worked extend to greater depths? And, secondly, are there likely to be valuable ore-bodies outside of those already worked?

ACKNOWLEDGMENTS.

The owners, operators and miners of the camp manifested the most courteous good will and extended cordial co-operation. Admission was cheerfully granted to every property, and assistance was willingly rendered. Mere thanks for such generous aid are totally inadequate. To name those by whom the work was facilitated would be to enumerate not only almost the entire staffs of all the mines, but everyone in Rossland who is specially interested in its mining development. Special thanks are due to the Centre Star Mining Co., which generously placed its sample grinding room and section-cutting apparatus at the disposal of the survey.

SITUATION AND TOPOGRAPHY.

Rossland is situated in the Trail Creek Mining division of the West Kootenay district, province of British Columbia, about six miles west of the Columbia river, and five miles north of the International Boundary line. It lies in the central portion of the Western Cordillera, in what has been called its Gold, or Columbian, range of mountains. To the east of the Columbia river, and separated from the Gold range by the Columbia valley, is the Selkirk system. The Gold range, or Columbian mountains, are, as a rule, less lofty and alpine than the Selkirks, and in the vicinity of Rossland rarely exceed 7,500 feet in altitude. Here, all the hills below 6,000 feet have easy, flowing outlines, the inequalities of detail having been erased by the Cordilleran ice-sheet. The camp occupies the head waters of Trail creek, which flows east to the Columbia, and the head-waters of Little Sheep creek, which flows southward to join the Columbia below the boundary line. To the west of Little Sheep creek is Record mountain ridge, about 7,000 feet in elevation, forming a

local divide. On its slopes Trail creek probably had its rise before these waters were captured by the headward growth of Little Sheep creek. This creek has now notched the transverse ridge from Record mountain, which separates Trail creek from Stoney creek on the north, thereby severing Red mountain (5,150 feet), from Mt. Roberts (6,450 feet), a shoulder from Record mountain. A second gulch to the east of Red mountain cuts it off from Monte Christo and C. and K. mountain, the continuation of this transverse ridge, and leaves Red mountain as a prominent dome. South of Trail creek are Lake Mt. (5,410 feet) and Look-Out mountain (4,420 feet). As a rule, the slopes are gentle, rising, on an average, about 1,500 or 2,000 feet in the mile. Roads may be run almost anywhere. The slopes were formerly well forested, but the demands of the mines and towns, and forest fires have largely denuded the hill sides of their timber. The climate is excellent. The summers are moderately warm and dry, with cool nights, and the winter climate is equable, the thermometer remaining remarkably steady, only a few degrees below freezing. The snowfall is heavy, but the clear air and sunshine and the absence of wind furnish an ideal winter. On the north side of Trail creek and almost at its head, perched on the slopes of Red and Monte Christo mountains, is the substantial city of Rossland, which for natural situation and general characteristics will rival any mining camp in the west. It commands a view of Trail Creek gulch and the Columbia valley 2,000 feet below, of the Selkirk mountains beyond, and of the ranges in northern Washington and Idaho. The elevation of the main street, Columbia avenue, is about 3,410 feet above the sea. The town is well built and is provided with a complete system of water works and drainage, local and long distance telephone, telegraphs, express companies, churches, schools, daily papers, board of trade, banks, &c., and all the industries required in a mining and self-supporting community. Ample power for all mining and industrial purposes and light is furnished by electricity, generated at Bonnington falls, on Kootenay river. Two lines of railways connect the camp with the outside world. The Columbian & Western railway joins it with the smelter town of Trail, on the Columbia river, and with Robson, Nelson and Boundary district points. At Robson connection is made with Arrow lake steamers, for the Canadian Pacific railway main line, and at Nelson with Crowsnest Pass branch. The Red Mountain railway unites Rossland with Northport, Wash., 18 miles distant, where the Le Roi smelter is located, which point the Spokane Falls and Northern railway connects with Spokane. The Kootenay district is remarkably well adapted for gardening and fruit raising, and the camp is well supplied with fruit and vegetables.

HISTORY.

Although lead was discovered on Kootenay lake (Blue Bell Mine) in the early twenties and was used as a source of lead for bullets by the Hudson's Bay Company, mining in West Kootenay is of re-

cent growth. In the early sixties, a few hardy prospectors came northward, attracted by the rich placers of the Cariboo, and tested and worked some of the local streams for gold. In 1865 the Dewdney trail was completed, from Hope, on the Fraser river, to the placers of Wild Horse and other East Kootenay creeks, passing close by the site of Rossland, down Trail creek. In the eighties, some claims were staked in the Boundary district; in 1883, at Ainsworth, on Kootenay lake, and in 1886, rich ore was discovered on Toad mountain, near Nelson. In 1887 the news of this discovery had attracted prospectors, and a trading post was established at Nelson. These discoveries started prospectors along the Dewdney trail, on the lookout for lode ores. The first claim located was the Lily May, on the trail itself. It was discovered in 1887 and relocated in 1889.

Although the gossan of Red mountain had attracted the attention of the earlier travellers along the Dewdney trail, some of whom, as Nelse Demers, had done a little work on it, the values were too low to warrant lode mining in a wilderness, with its costly transportation and development; placer mining, naturally, absorbed their interest. It was not until 1890 that claims were located on the lodes which were to create the city of Rossland and to bring southern British Columbia prominently before the mining and commercial world.

In the summer of 1890, Bourjois and Morris, who were working on the Lily May, crossed over to Red mountain and located in one day the Le Roi, Centre Star, War Eagle, Idaho and Virginia. These claims were recorded at Nelson, the Le Roi being given to E. S. Topping for paying the $12.50 recording fees. He secured specimens and went to Spokane, interesting some business men of that town in the Le Roi, and the development of the camp began. The news of the strike brought prospectors, and the Josie and most of the other claims whose names became so familiar, were located shortly after the first discovery—many in the same month.

Development was for the first few years slow, and the prospects of the camp uncertain. Lack of transportation and the financial panic of 1893 were the chief deterrent factors that nearly wrecked the fortunes of the camp. The first ore sent out of the camp was a small lot in 1891, which was packed to the Columbia river and thence shipped to an American smelter. In 1893, a waggon road having been constructed to Trail, on the Columbia, about 700 tons were despatched. The results were sufficiently reassuring to justify the erection of machinery, and with improved facilities, 1,856 tons of ore, shipped in 1894, returned $75,510. During the summer the Geological Survey, through Mr. R. G. McConnell, made a reconnaissance survey of the camp. Several of the more important properties were bonded for considerable sums and development was begun in earnest. The following year, the young camp received marked attention. The population rose from 300 to 3,000; railroad

and smelting facilities were projected, and from this time forward, developments were rapid. The smelter at Trail, and a tramway to connect it with Rossland and the mines, were begun in October, 1895, by Aug. Heinze, of Butte, and the first furnace was blown in the following February. In 1896 the Red Mountain railway, connecting Rossland with the Spokane Falls and Northern railway at Northport, was completed. Then came the inevitable wild boom. The evil effects of a boom are not confined solely to the thousands of dollars squandered in worthless property, the losses sustained by the innocents, and the damaged reputation of the district, but they are manifest in careless work on deserving claims, in a rash expenditure that may for some time survive the boom; in a loss of interest in properties of merit that only require additional work to demonstrate their worth; and in a tendency to maintain prohibitive prices on promising prospects by owners who have purchased during the period of inflation and are not prepared to accept a serious loss, or by owners who, once having experienced the sensation of being millionaires, are loath to accept present conditions, but prefer to speculate on the improbabilities of the future. Rossland has been called on to pay in full all the penalties attaching to a boom. The phenomenal rise in the value of Le Roi stock, the dividends declared by this company and the War Eagle, and the sale of the latter, to Toronto capitalists, for the reported sum of $700,000, produced a feeling of buoyancy that afforded every opportunity to the unprincipled boomster and the amateur mining magnate, the public for the time being cheerfully swallowing whatever was offered. The inevitable slump followed.

In 1897 Rossland had an estimated population of 6,000 and was incorporated as a city. A broad gauge railway was built from Trail to Robson, giving better connection with the Canadian Pacific railway than was afforded by river navigation along this rapid stretch of the Columbia. Stronger companies were formed to take over and develop promising prospects. In particular, the British American Corporation purchased the Josie, Nickel Plate, Great Western, Poorman, West Le Roi, Josie, No. 1, and Columbia-Kootenay mines. Development work had yielded most promising results. The Le Roi Company, having completed its contract for 75,000 tons with the Trail smelter, erected its own smelter at Northport. In 1898 the Canadian Pacific railway purchased the Trail smelter and railway from Heinze, and immediately made an important reduction in smelting charges. The British American Corporation secured the Le Roi mine and smelter by purchasing the stock at a price which was said to represent nearly $4,000,000 for the property. The Centre Star was purchased by Toronto capitalists for $2,000,000 cash. The construction of the Crowsnest branch of the Canadian Pacific, built through the Crowsnest coal fields to Kootenay lake, was an important event for the camp. It meant cheaper and better fuel and coke, and a consequent reduction in cost of ore production and treatment.

These reductions brought about a large increase in ore tonnage with corresponding diminution in the grade of ore mined. Large plants with the most approved machinery for the economical working of the mines, were installed or planned, and operations on a large scale were projected. The construction of the West Kootenay Power Company's plant at Bonnington Falls, 32 miles distant, was another important event. Electric power was now available for the Trail smelter and the Rossland mines, although full use has not been made by the mines of this most convenient and economical form of power. At the close of 1899, the reputation of Rossland suffered from the sudden collapse in the price of War Eagle stock. This stock had been run up to a wholly unwarranted point, and was held in the hope that new machinery would permit an increased output, with a resultant advance in the stock. Unfortunately the machinery proved a failure, and the stock dropped. A general desire to realize followed and brought about a collapse, with a consequent loss of faith in the camp. In 1901, Rossland again received a set-back, this time in the form of labour troubles, which closed up the mines for a part of the year. These difficulties were amicably adjusted, but the evil effects of such troubles in discouraging investments are not quickly effaced. By 1902 the mines had resumed their normal operations and on a more business-like basis than before. Although the great number, size and value of the ore shoots in these mines have been proved, and it is known that much lower grade ore can now be profitably worked, this has so far not had the effect that might be expected in encouraging the search for other pay shoots and new veins outside the area already developed. Experiments in concentration were commenced in 1903 and are still being made, and serious efforts are being made to obtain the greatest possible profit per ton of ore.

The development and progress of mining is reflected in the following table of production.

	Tonnage (long tons)	Smelter returns	Value per ton
1894..	1,856	$ 75,510	$40 69
1895..	19,693	702,457	35 67
1896..	38,075	1,243,360	32 65
1897..	68,804	2,097,280	30 48
1898..	111,282	2,470,811	22 20
1899..	172,665	3,229,086	18 70
1900..	217,636	2,739,300	12 59
1901..	283,360	4,621,299	16 31
1902..	329,534	4,893,395	14 85
1903..	360,786	4,255,958	11 80
1904..	312,991	3,760,886	12 01
1905 (estimated).	295,589	3,750,000	12 70
Total..	2,212,271	33,839,342	15 25

Shipments by mines to December 31, 1905 (estimated).

Le Roi	1,220,175
Centre Star	417,529
War Eagle	357,814
Le Roi No. 2	173,035
Jumbo	28,422
Iron Mask	17,655
Rossland-Kootenay	12,878
Rossland-Gt. Western	12,331
Velvet-Portland	7,751
Spitzee	6,709
White Bear	5,973
Giant	4,344
I. X. L.	3,500
Evening Star	1,500
Monte Christo	400
Miscellaneous	1,200

The development work in the four leading mines is now in the neighbourhood of 24 miles, and is at present advancing at the rate of about four miles per annum.

OUTLINE OF GEOLOGICAL HISTORY.

The geological history of Rossland is largely a record of volcanic activity, of which, for an unusually great portion of geological time, it has been a centre. So far as understood the chief events have been as follows:—

In the Carboniferous period, stratified rocks, consisting of clays, limestones and perhaps quartzites, were laid down in an early ocean. Some volcanic outbursts occurred during this time, whose tuffs, ash beds and lava flows were included in the stratified series. These rocks are now found very much disturbed and altered west of the Josie gulch, and on Red mountain and at various points about the outskirts of the camp. Succeeding the formation of these rocks, probably in Mesozoic times, came a period of heavy vulcanism. Beds of volcanic agglomerates and conglomerates were formed and thick flows of lava were poured out over this sedimentary basement. The remains of these are represented by the agglomerates and augite porphyrites found near the mines, The volcanic centre was probably the area occupied in the centre of the camp by the main mass of monzonite, which was intruded into the rocks already present, for notwithstanding the occasional apparent transition between the two rocks, the monzonite generally appears to cut the porphyrite. The surface of the ground must then have been above its present position, for the mass of molten rock matter certainly cooled well below the surface in depth. Later intrusions of closely

related rocks invaded the monzonite and some of the older formations, near its contact. From the voluminous magma of the Nelson granodiorite, tongues were sent out, one of which, now exposed on the Little Sheep creek slope, cuts the monzonite mass.

No doubt some of these great eruptions accompanied mountain building processes, which disturbed and fractured the rocks. Some of these fractures were filled with magma from the eruptives, which may now be seen in the older system of dikes. The exact geological dates of these events, and the time interval between them, have not yet been made out, but the eruptions probably extended into Tertiary times. In this period, surface flows of lava again took place. Andesites and tuffs of Beaver mountain and certain andesites and agglomerates of Record mountain, probably belong here. In an interval of quiescence, streams formed beds of gravel over some parts of the neighbourhood. Remnants of these are to be seen in the conglomerates on Sophie and Lake mountains. But tranquil conditions were not lasting, for vulcanism burst out afresh on a more extensive scale than ever. Ash beds, tuffs, and great thicknesses of lava flows were probably piled up as a thick mantle, connecting with other lava fields to the westward, and with the Columbia lava field of Washington and Idaho. Erosion has laid bare, in the neighbourhood of Rossland, large stocks of pink alkali syenite with some basic facies that have intruded and sent dikes into all the previous rocks. The main mass lies on Granite mountain and westward over Sheep creek, but a tongue of it runs south towards Little Sheep creek, crossing the Jumbo claim. A small neck of it comes up north of Columbia avenue and west of Centre Star gulch, and a small boss on the Spitzee and southwest of it. These stocks no doubt represent channels by which the later lavas reached the surface. The centre of volcanic activity had now shifted a little to the west of its original position in the camp. Following the intrusion of this rock—to some extent, perhaps, concurrently, and as a result of it—came a period of intense fracturing of the country rocks, accompanied by much, but generally minor, faulting. Certain beds were minutely sheared or fractured. The main directions of fissuring were a little west of north and south of west, but irregularities in direction and branching of the fissures were common. The rocks became impregnated with "mineral" matter, brought in by heated waters, chiefly along and near the fissures in sheared zones with an easterly trend, but to some extent in those with a northwesterly direction. The fracturing and faulting of the rocks, some of them now holding veins, continued, fissures with a northerly trend predominating.

A very large number of these were filled with dikes, in which various rocks are represented. A great number of the dikes, including some of the largest, are mica lamprophyres (basic dikes in which mica is the conspicuous mineral). Others are non-micaceous, some basic and some acidic.

In the mines the dikes are usually classed as "mica dikes" and "non-mica dikes." These are not all of precisely the same age, their formation having continued over an interval of time, and later injections crossed earlier injections, or came up alongside or within them, forming compound or mixed dikes. Dikes belonging to these dates cut—and in many cases fault—the ore bodies. Dikes of the earlier eruptions are also pierced by them. Faulting continued after the later injection of dikes, displacing such as were not parallel to the faults. Indeed, much of the displacement of the veins by dikes is in reality due to faults in or along the dikes. Subsequently, the agents of erosion attacked the old surface, cut away the topographical features produced by the volcanic eruptions, and sculptured out the present surface relief. The streams have been the chief factors in this, but a [illegible] deal of the present aspect of the district is due to the action of the Cordilleran glacier which, at the close of the Tertiary period, bore down upon the district from the north, burying all the valleys and the lower hills and ridges under a thick ice-mantle. The ridges and peaks above 6,400 feet stood out like islands above the sea of ice. The ice-sheet swept away the loose and rotted rocks, scoured and polished the underlying live rock, and erased rugged and outstanding shoulders. In favourable localities ground-moraine was left by the glacier. Some of this may be seen in excavations in the town of Rossland. At the close of the period of intense glaciation, the Columbia, like other valleys of southern British Columbia, was filled with water, in this section at least, to the height of Rossland. Whether this was due to the sinking of the land, or damming of the valley by a lobe of ice, is not clear. These waters worked over a large amount of the glacial debris, and redeposited it as clays, sands and gravels, terraces of such material marking successive stages in its retreat. Much of this material has since been carried away by erosion, but in favourable localities, as between Rossland and the Columbia, it still remains. During the period of erosion, surface water, descending through the fissures and pores of the rocks, rearranged to some extent the minerals of the ore deposits, concentrating certain minerals in what are now the upper portions of the deposits. Underground waters, either from the surface or given off by the cooling rock magmas, also concentrated ore in the deposits against many of the dikes which cut the veins; in a few cases these waters made rich deposits that extend for a short distance from the veins in fault planes which intersect them. Surface oxidation only extends to a depth of a very few feet.

ORES.

The ore deposits occur (1) In fissure veins, with or without replacement of the country rock.

(2) In lodes or zones of fissuring or shearing, with the ore minerals forming a network of veinlets in the fractures, and eating into

and replacing in whole or in part the intervening fragm[illegible] of the country rock, replacing the wall rock, or developing along [illegible]rticular fractures.

(3) As irregular impregnations of country rock.

What have, so far, proved the most important ores [illegible] in (1) and (2).

On the basis of mineral contents the deposits may be [illegible]sified as:

(*a*) Massive pyrrhotite and chalcopyrite ores with some pyrite and occasionally a little arsenopyrite, massive or mixed with rock matter and gangue. Free gold occurs, but it is rarely to be seen with the naked eye, altho[illegible]h the proportion of free gold run[s] from 10 per [c]ent to 50 per cent of the total gold contents. Rarely, [illegible] molybdenite and magnetite are found in this, the typical [o]re of the camp. Galena and blende have been found at one or two po[ints]. The pyrrhotite at times contains up to ·65 per cent nickel and [illegible] cobalt.

(*b*) Massive coarse-grained pyrrhotite car[illegible] and little gold.

(*c*) Veins of pyrite and marcasite with ar[illegible] and [illegible] galena and blende. (South Belt.) Silver m[illegible] in [illegible] part of the values in such veins.

(*d*) Impregnations of arsenopyrite, pyrrh[illegible] [illegible]nite, a little chalcopyrite, bismuthinite and [illegible] in and around small pegmatitic or aplit[illegible] (Giant, Jumbo.)*

(*e*) Gold bearing quartz veins (O.K. and [illegible]

The gangue is principally country rock, wi[illegible] qu[illegible] places, calcite. This country rock is frequentl[y] [illegible]red, to its impregnation or replacement by the sulph[illegible] miner[alization] ation of biotite and silica (sometimes in separa[illegible] tuting a banded brown and white rock), is the p[illegible] but chlorite and hornblende are also extens[ively] [illegible] and muscovite, tourmaline, garnet and woll[astonite] [illegible] lites (chiefly anthophyllite and chabazit[e] [illegible] where alteration by thermal solutions is m[illegible]. [illegible] served in the Jumbo (†), where molybd[illegible] uncommonly prevalent. The ore varie[s] [illegible] and composition in different parts of the [illegible] mi[illegible]

Typically, it consists of more or less alt[ere]d rock [illegible] in places fresh-looking rock is seen, with reticulatin[g] [illegible] lar masses and impregnations of pyrrhotite and [illegible] of chalcopyrite and perhaps a little quartz, th[illegible] 50 to 75 per cent of the mass. The chalcopyrite [illegible]

(*) The arsenopyrite in this camp is frequently [illegible] iferous.

(†) Telluride of gold is said to occur in Jumbo ore, but [illegible] we have so far examined have failed to respond to tellurium [illegible]

in forming than the pyrrhotite, occurring in veins and impregnations in it. Sometimes arsenopyrite and pyrite occur with the chalcopyrite. From this typical ore all transitions occur, on the one hand, to solid sulphides, forming larger masses or shoots; on the other to rock matter or gangue with little apparent mineralization, but carrying pay values, and sometimes a high percentage of gold. Consequently, constant assaying is necessary to distinguish ore from waste. In places, the ore is quartzose, and calcite is occasionally abundant as gangue.

The values in typical ores of the camp are largely in gold, with some copper and a little silver. In the Giant and Jumbo the quantity of copper is negligible.

The ores mined from near the surface were, on an average, much richer, the first 128,428 tons shipped averaging 1·46 oz. of gold per ton, 1·96 oz. of silver per ton, and 1·73 p.c. of copper (after smelter deduction of 1·3 per cent). But the proportion of *free* gold does not appear to diminish in depth, and some of the ore recently encountered in the lowest levels compares favourably with that of the earliest shipments. The gold values do not appear to be dependent upon the presence of any one mineral, although in many cases ore richer in chalcopyrite is also richer in gold but exceptions are frequent. Pyrrhotite, which, in some instances, is gold bearing, is, in general, very low grade.

The following average analyses may be taken as typical of the ores now being mined in the larger producers.

Au. oz.	Ag. oz.	Cu p.c.	Fe. p.c.	SiO_2 p.c.	S. p.c.	CaO p.c.	Al_2O_3 p.c.
·44	·5	1·15	19·8	43	7·25	8·7	[illegible]
·5	·3	·9	22	37	10·8	4·2	14·9
·4	·54	·7	15·5	42·1	6·8	17·6	
1·18	2·318	3·62					

LODES.

The ore is usually found in well defined lodes or veins of which there are a considerable number in the camp. The general trend of these is for the most part easterly.

The chief lodes of the camp, the Le Roi-Centre Star, Main and South and the Josie lodes have a direction of about N. 60° E. The Le Roi North, War Eagle and Centre Star north veins have a trend of N. 70° W., and these seem to be offshoots from the "main" lode. The St. Elmo-Cliff-Monte Christo vein has an almost easterly direction. The dips are uniformly north, usually at an angle of from about 60° to 70°, although sometimes flattening, as in the War Eagle below the 8th level, where the vein dips away at an angle of 10° to

15°, though straightening up again at a lower level. Some of the veins show great persistence. The main Le Roi-Centre Star vein can be followed from the fault at the Josie dike through the Le Roi, Centre Star and Idaho claims and probably extends thence to the Kootenay claim.

As is to be expected from the nature of the lodes, sharply defined walls are frequently lacking, the mineralization of the country rock gradually becoming less. Sometimes a fissure or fault plane bounds the ore, but often where this is the case, the slip has been formed after the mineralization. The transition from pay ore to what is—from a commercial standpoint—waste rock, is generally rapid, but such change is not proof that pay ore does not exist beyond the poor material. The pay ore is localized in shoots distributed within the lodes. These shoots vary greatly in size and shape. Lenticular bodies are commonest, but some terminate abruptly against a dike or fault, sometimes swelling to an enormous width or becoming L-shaped against the dike. In width, they vary from a foot to, in exceptional cases, 130 feet; in length, from 50 to 500 or more feet, and the vertical dimension is on an average the greatest. Stopes, 250 feet long by 20 to 30 wide, are by no means uncommon. One shoot of ore that has been followed down nearly 500 feet vertically, has averaged at least 150 feet long by 56 feet wide, and this is not the largest shoot that has been developed. The pitch of the shoots in the lodes varies from vertical to pronounced easterly or westerly and seems dependent upon purely local conditions. In the shoots themselves, the better grade ore is often confined to particular bands, which are generally parallel to the vein, but which may lie along either wall or within the shoot; more than one such band may be encountered in running a cut across a shoot. The position of such rich bands in the lode may suddenly change, owing to the mineralization forsaking one set of planes for another. In the Le Roi and Centre Star, where there are two important parallel lodes—the "Main" and "South Veins"—it would seem, in the light of present developments, that where important shoots occur in the one vein, heavy mineralization is lacking at the corresponding point in the other. It is sometimes difficult to trace the vein from shoot to shoot, particularly where its continuity is interrupted by faults and dikes. In the Le Roi-Centre Star Main vein, a seam of calcite extends almost uninterruptedly along the vein, and occasionally forms a useful indicator where mineralization is slight.

Until it is more fully known what were the determining factors in localizing the ores into shoots, no certain rules for their discovery can be formulated. Apparently several causes were operative. The contact of the lode with a fault having an impervious wall, or with an important dike—particularly the underside of the dike—so frequently marks the position of an ore shoot, that all such contacts are worth prospecting. The physical character of the ground was of importance. Where the shearing of the rock was such that the

mineralizing solutions were restricted within a zone of reasonable width, but had free movement, within that zone—that is, where the rock within that zone was thoroughly fractured while the wall rock as a whole is characterized by solidity—conditions were favourable and, other things being equal, a shoot would be formed. Cros fractures in the otherwise solid wall rock are frequently a noticeable feature where ore shoots occur. In the Le Roi the ore shoots are generally, but not always, found along the contacts between the augite porphyrite (greenstone) and a rather coarse gray monzonite, and between the former and granodiorite porphyry. In some cases at least, the main lode lies along the north contact and the south lode along the south contact of a belt of the latter rocks in the porphyrite. In the lowest levels the whole of the country rock is the granitoid variety.

The main ore body of the Jumbo has not the outlines of a vein deposit, but is of very irregular form. It lies in the highly altered stratified rocks against a tongue of alkali syenite, and consists of altered country-rock, traversed by numerous dikes from the syenite, many of them dipping at only slight angles from the horizontal. The rock is impregnated with iron sulphide, chiefly pyrrhotite, and in places is almost entirely replaced by it. Pyrite, molybdenite, a little arsenopyrite and chalcopyrite are found. In the mineralized ground, bismuthinite with free gold is found in the dikes, and in the country rock, close to the contact, or in joint planes. The greater dimension of the mineralized area seems to conform to the direction of the syenite contact.

The Giant also lies in the stratified rocks, and is in some respects similar to the Jumbo, but the main minerals of the ore are arsenopyrite and molybdenite. Syenite is found in the mineralized ground. The country rock over a wide area from the Giant workings northward, is spotted with arsenopyrite impregnations. In the south belt few of the workings could be entered. The Homestake shows a persistent, but much faulted, E. and W. vein, mineralized with pyrite, some pyrrhotite and a little chalcopyrite.

COUNTRY ROCKS OF THE VEINS.

All the rocks with the exception of the later dikes, may be mineralized. The alkali syenite rarely shows any signs of mineralization except in the slight impregnation of little dikes in the Jumbo, and a few stringers near the Spitzee vein. Augite porphyrite and the coarser gray granitoid rocks are the ore-bearing rocks of the north belt mines—the producing mines of the camp. These lie on the complex, northwest border of the large monzonite area, and near the contact of the porphyrites with the stratified rocks. A strong tongue of alkali syenite (*Pulaskite*) lies just west of the Jumbo; mineralization occurs here; signs of this syenite occur in the Giant ore body, a small pipe of it is exposed a little below the Le Roi and Centre

Star mines, and a larger mass of the syenite is to be found a little farther south, adjoining the Spitzee. Thus, the ground which, up to the present, has been proved to be productive, is situated either near or within a limited distance of the alkali syenite and lies between the exposures of the latter. The greater part of the ground so situated is made up of the stratified rocks. Except from the Jumbo and Giant, however, no important shipments have been made from claims located on these rocks. This is not because these stratified rocks do not show signs of mineralization, for, in the aggregate, they have probably received more ore than the porphyrite, but because of their physical character. Under the great dynamic stresses to which the rocks of this camp were subjected, they were completely shattered and minutely faulted, and consequently they did not, to the same extent, confine the mineralizing solutions to particular channels, but allowed them to deploy over wide areas. The mineral deposited in these stratified rocks, therefore, while occasionally in small veins or bodies, is usually found diffused over great stretches of the rock. Crystals, patches and veinlets of arsenopyrite and the other sulphides are scattered a few inches apart over quite extended tracts. The characteristic colour of Red mountain is due to the oxidation of such impregnations. The physical character of the stratified rock was, therefore, not so favourable for the formation of lodes as that of the coarse monzonite and porphyrite, and in so far as the physical character was a controlling factor in the formation of ore, workable ore bodies were, to that extent, less likely to be formed. The chemical character of these rocks as a whole may have also been less favourable, so that replacement and precipitation of the ores occurred only at small isolated points. In the White Bear, the workings to the 500-foot level are in the stratified rocks, and it was not until the underlying crystalline rocks were reached that anything like a lode was found. In the Columbia-Kootenay the ore for a considerable distance follows the contact between a granitic rock and the stratified rocks. In South belt, the Homestake and a number of other claims are in the complex altered rock outside the monzonite area.

GENESIS OF THE ORES.

From the way in which the ore occurs in veins and lodes and replacing the minerals of the various country rocks, it is evident that the deposits were formed through the agency of aqueous, mineral-laden solutions. Any doubts on this point are removed by an examination of thin sections of the ore under the microscope, which shows the secondary origin of all the ore minerals, and the gradual replacement of the original components of the rocks, particularly the feldspar, by them. In the polished hand specimen, veinlets of the sulphides are seen to cut through individual crystals, such as augite, of the country rock. From the character and relation

ship of the minerals formed, it may fairly be concluded that these solutions were at a high temperature hydrothermal solutions. The temperature of the solutions, the fact that the lodes at times branch or give out going upward, the concentration of ore on the under side of dikes, the strongly reducing conditions shown, and the general character of the minerals, all tend to prove that these were ascending solutions. The source of these solutions and that of their mineral contents must be largely a matter of speculation, although the facts point strongly to their connection with the last stages of vulcanism in this district. The material was not derived from the immediate country rock, for the ore occurs in various rocks, and the materials of the lodes are found in these rocks only along the contacts of such lodes, except in the case of the stratified rocks, where the dissemination is accounted for by the physical character of the rock. The deposits were formed later than the rocks, excepting only the last formed dikes which are clearly newer than, and cut the lodes, but are probably connected with the alkali-syenite intrusion. Consequently, the lodes were formed after the extensive intrusion of the alkali-syenite, but before the close of vulcanism. The occurrence of ore at the Jumbo, described above, closely connected with the syenite contact, and with its dikelets, as well as its mineralogical composition (pyrrhotite, pyrite, arsenopyrite, molybdenite, bismuthinite, &c.), strongly suggests the causative influence of the syenite eruption—that the gases and aqueous solutions liberated by the solidifying syenite magma had much to do with the formation of this ore body, if they were not altogether responsible for it. The ores of the lodes and vein systems differ from those of the Jumbo, not in the variety of minerals contained, but only in their relative proportion. Since they also were formed during this period of vulcanism, it seems probable that they were formed by solutions from a similar source, but in composition somewhat different, possibly on account of having travelled a greater distance. Even if it were not evident that the deposits were formed during a period of vulcanism, the connection of the deposits with igneous intrusion would be suggested by the assemblage of minerals.

Of the minerals characteristic of contact metamorphic deposits the following have already been recognized here—garnet, wollastonite, epidote, amphibole, pyroxene, quartz, calcite, magnetite, chalcopyrite, pyrite, galena and blende. These minerals do not occur in the same relative proportions as in typical contact metamorphic deposits, but their occurrence is suggestive of transitional type between such deposits and ordinary vein or lode deposits. Going westward to the Boundary district, various transitional forms and typical contact deposits are found. Of the minerals characteristic of hydrothermal action, there are tourmaline, muscovite, chlorite, zeolites, molybdenite (occasionally in large amount), arsenopyrite, bismuthinite and sulphides holding nickel and cobalt. The formation of the lodes was no doubt a long continued operation. Some pyrrhotite

was formed before chalcopyrite, for the latter is found in veinlets in the former, but in other cases it is probable that the formation was also contemporaneous. There is good ground for believing that the formative period of the lodes lasted until after the injection of the last dikes.

There is little surface oxidation, except along some few fractures, the iron and copper sulphides remaining unchanged within a few feet of the surface. If deep weathering took place, all trace of it has been swept away by glaciation. The actual outcrop is a brown iron gossan, if the ore is solid sulphides, or an iron-stained rotted rock if the ore is mixed. Slight copper stains of copper carbonate and silicate may be sparingly present, and in protected places an iron sulphate coating may occur. As might be inferred, no zone of rich copper sulphides occurs below the oxidized surface. The average copper percentage of the ores in the upper levels of the mines was appreciably higher than in the lower levels; the same is true of the gold values. It must be remembered, however, that the difference between the values of ore shipped in the early days and that shipped at present, only in part represents a lowering of the grade of ore in depth. In part, it is the result of mining a lower grade material that formerly would not pay, but which, under present conditions, is profitable ore. There is a strongly marked tendency for the ore shoots to widen and become more important against dikes (especially along the under side) that cut and displace the lodes. In a few instances, fault planes, subsequent to the ore, are mineralized for a short distance from the lode; chalcopyrite is found in points and veinlets in the pyrrhotite. Several hypotheses may be advanced to explain these facts.

(1st.) They may be regarded as evidence of secondary enrichment from above. The minerals formed by hydrothermal solutions may have been rearranged and concentrated by the ordinary underground waters working downward. In some veins this method of enrichment seems to have obtained for a limited depth, but on the whole it seems to have been a superficial phenomenon. The compressed state of the rocks does not favour the circulation of waters.

(2nd.) The diking and faulting may have occurred during the process of lode formation, and ascending solutions, after their formation, were deflected and accumulated by the barriers thus produced. The precipitation of mineral was more abundant along these barriers, and copper and gold found more favourable conditions of precipitation at the higher levels. Well authenticated instances of original differences in veins at different elevations are on record.*

(3rd.) After the first deposition of the ore, water heated by recently injected igneous rocks, or given off by the still solidifying magma, might continue to ascend, though no longer of the original composition, and these waters might deposit new minerals in the ores, or might rearrange and concentrate the ore minerals already

* A. I. M. E. Genesis of Ore Deposits, p. 670

present. Conclusive evidence on these points has not yet been obtained. Such as there is, eems to disfavour the first and support the second or third hypothesis.

Denudation has been heavy, so that the present surface is probably far below what was the surface when the lodes were formed; a large amount of this denudation was no doubt accomplished by the Cordilleran glacier. The source of the solutions was deep-seated. It is reasonable to suppose that, in ascending, there was a level where precipitation commenced, another where it reached a maximum, and possibly, approaching the surface, still another where, on account of the waters having been largely robbed of their treasure, precipitation diminished. Ascending currents would be more likely to follow the underside of the dikes. One of the latest actions to be discovered in the lodes is the solfataric-like alteration of the rock and the formation of zeolites at certain points in the mines. Recent sinking to deeper levels (1,550 feet), in the Le Roi and Centre Star, and prospect work on the lowest level of the War Eagle, have disclosed ore that compares favourably with any from the surface workings. Silica, however, appears to be increasing. In the Centre Star South lode, near the shaft, the sulphides are disseminated on the 7th level. On the 8th, there is a tendency toward concentration into shoots; on the 9th, the minerals are sufficiently assembled to constitute ore that continues with some improvement to the lowest workings, 200 feet below the 9th level. In the Le Roi a similar condition is met with. The 1,350 foot level (corresponding in elevation to the Centre Star 9th) shows the top of an ore shoot that improves in value to the 1,450 foot level, and which has now been followed to the 1,550 foot level, at present the bottom of the mine. These facts indicate either that there were original differences in the vertical distribution of values—just as there are horizontally, as shown by the difference in the grades of various stopes on the same lodes—or that, if secondary enrichment has taken place, it was produced by ascending solutions.

It is nevertheless true that outcropping veins often show some surface enrichment, in some cases to a considerable distance below the weathered surface. It is evident, from the discussion on the distribution of ore in shoots in the vein, that this does not mean that the ore of deeper workings will necessarily be of lower grade than that near the surface, but only that the grade of the ore of that particular part of the vein has been raised, perhaps very materially, by surface concentration. A better ore shoot at a deeper level, unaffected by surface action might contain a still higher grade ore. Consequently, great care, and a close study of the conditions in any given case, are necessary, before drawing conclusions as to the probable grade of ore to be expected below.

FUTURE PROSPECTS.

Since enrichment by descending waters does not seem to have been of great consequence in these lodes, except in some cases superficially,

and since the mineralization has been accomplished by ascending hydrothermal solutions, there is, as yet, no apparent reason why pay ore should not continue in depth. The shoots followed on the main Le Roi-Centre Star lode give out between 800 and 1,050 feet, and have, so far, not reappeared below. Ore was lost in the War Eagle at about the same depth, so that for a time it appeared as if ore bodies might not occur at deeper horizons. But work on the South lode shows extensive mineralization which improves in successively lower levels, and in the lowest levels, shoots with pay ore have now been located. As noted above, there are facts suggesting that where the main lode is not heavily mineralized, the solutions may have followed the South lode, i.e., that the main highway for the mineralizers was, in part of their course, the South lode, and, in part, the Main lode. Recently, Superintendent Stewart of the Centre Star-War Eagle mines, has found that below the 8th level, the War Eagle vein flattens to 10° or 15°, which throws the vein away to the north and accounts for the failure to discover ore in the lower workings. Diamond drilling on these lower levels shows that the vein again straightens and that ore is continuous to the 11th and lowest level of the mine. A cross-cut on this level to the vein is said to have revealed good ore for a width of 20 feet.

Though it cannot be predicted to what depth pay ore will extend, it may be said that the prospects for deep mining in Rossland were never before so favourable as they are at present, and that operating companies are justified in pushing prospecting to deeper levels.

Notwithstanding the heavy shipments from the mines and the extensive prospecting done, there is still a considerable amount of promising ground above 900-foot levels as yet insufficiently prospected, or even untouched. The mode of occurrence of ore shoots, [illegible]ly described, and the past experience of the mines, that follow[illegible] poor parts of the vein, horizontally and vertically and cross-cutting for parallel ore bodies, will often disclose good ore bodies, render it more than probable that certain portions of such areas contain ore. It should be remembered that little indication of pay ore may be found until the shoot itself is encountered. In one instance, two good stopes were separated by an interval of vein, which was indicated to be low grade by neighbouring ends of the two stopes, and by drill holes from the connecting drift (which was off the vein), yet a subsequent drift on the vein showed that a whole stretch between the two stopes was pay ore, except a couple of feet at the ends of the stopes and the points pierced by the drill holes. A large stope was opened up as the result of this discovery.

Somewhat similar discoveries have been and are yet frequently made; ground thought to be valueless has proved valuable, and this will no doubt continue for some time. Mineralization has been so heavy and so complicated that all the ground near the highly productive shoots is worth bold though judicious prospecting. Outside the producing ground, there are points that are worth exploration.

For instance, the Le Roi-Centre Star vein east of the Centre Star gulch should certainly receive attention. Ore of good grade was shipped from the Iron Mask vein. The well marked vein of the St. Elmo-Cliff Monte Christo has produced several hundred tons of ore that average about $20, and a considerable tonnage of low grade ore that has an excess of iron over silica, such as is desired by some of the smelters; small quantities of good grade ore have come from other properties. To the north of the camp and in the south belt, bodies of low grade have been exposed. There are large numbers of claims that have a considerable amount of work done on them. Many have proved to be of little worth. In other cases the result of the work, while not absolutely conclusive, has been discouraging. Some may have had ore that, while too low grade to be worked some time ago, would be payable to-day. It must, however, be remarked that the work done in a surprisingly large number of cases has been of such a nature as to furnish little evidence regarding the value of the veins. In more than one instance it seems to have been a matter of unusual good fortune if the vein was touched once or twice in the whole extent of the workings. It is evident that the nature of the ore bodies, and the effects of dikes and faults were not understood when the earlier work in the camp was carried out.

From the remarks made concerning the occurrence of pay shoots in the productive ground, it follows that a vein or claim should not be condemned simply because a limited amount of prospect work has failed to reveal pay ore. Occasionally, a productive vein, or the productive part of a vein, has an insignificant outcrop, or none at all. Where, however, the ground is excessively diked and broken by numerous fractures and faults into small blocks, it would seem to have little chance of containing ore shoots that can be profitably extracted. Where geological conditions are dissimilar to those in the productive area, and where no pay ore is exposed on the surface or elsewhere in the vicinity, the possibilities of the presence of ore are meagre. Considerable stretches of the surface are drift-covered and of these, if the area be considerable, little certain knowledge is to be had, for changes in the formations in this camp are too numerous and irregular to make interpolations thoroughly reliable.

Judging from the surrounding rocks, and from what few exposures are to be seen, the ground between the Annie, Le Roi and Centre Star, and a line a little west of south from the Spitzee should in certain portions at least, resemble closely, in its geology, the ore-producing ground, and might very well contain important ore bodies.

The contact of the alkali-syenite (*Pulaskite*) at the Spitzee and at the Jumbo, is ore-bearing, and might be at other points as well. The South belt, along the southern edge of the monzonite area, has a number of veins, from some of which good values have been reported. The only shipments of importance were from the Crown Point, near the southeastern edge of the monzonite area. This claim is reported to have had a good shoot of ore, until a fault was en-

countered, below which nothing has been found. It has shown, however, that at least at one point in this belt, shipping ore occurs. All but a very small fraction of the ore so far produced has come from an area covering scarcely 100 acres on the northwest corner of the monzonite area, which was the first ground staked on the Red mountain. When it is remembered that many of the good ore shoots did not outcrop and that mineralization is heavy over a very large area in the camp, it is unreasonable to suppose that pay shoots are confined to the few earliest locations. While development [illegible] shown that ore in workable quantities is much more restricted than was expected during the exciting days of the boom, it has [illegible] means exploded all possibility of further discoveries.

The stratified rocks in places are impregnated with arsenopyrite and other sulphides. The rock matter is usually very [illegible]. Such material, if it contained values, could be very cheaply mined or quarried, and might be amenable to a cheap process of treatment. Samples were taken from the surface of such an impregnated band, running north from the Giant workings, through the west end of the Novelty. The exposures were laid off into blocks, and [illegible] samples, systematically taken from the surface, were pulverized and reduced to convenient bulk for assay. While such samples are not absolutely representative they should afford some indication of the contents of the rock. Of twenty-three lots taken, twelve gave the following results per ton in gold: Two went \$1.20, four went \$1.60, one \$1.80, two \$2, two \$2.40, one \$3.60, and one \$4. Five gave results under \$1 and six yielded only traces of gold. A large sample averaging \$2.30 was taken, and is undergoing concentration tests by Prof. J. C. Gwillim at the School of Mining, Kingston. It would appear from the foregoing that the more heavily impregnated areas of these stratified rocks are deserving of more careful tests as to values and amenableness to concentration or cyaniding. If the values are distributed throughout a considerable mass of such rock, so as to ensure a large tonnage, and concentration, or cyaniding is successful, two dollars and a half or three dollars, or perhaps an even lower grade rock, might be profitable.

It is to be emphasized that the present conditions are much more favourable for cheap mining and smelting than formerly, as a glance over the section of this report on Costs of Operation will show.

While it is conceivable that costs may be still further reduced, it is uncertain, and it might easily happen that future conditions would be less favourable for operating than the present; so that the present seems to afford the most favourable opportunity for [illegible] projected prospecting, development and mining. That this is the case, is shown by the leasing of old claims by practical miners, which was a marked feature in the past year's operations.

There are a large number of prospects now idle, equipped with serviceable compressors and hoisting gear, which machinery could probably be secured at a reasonable price for such development work.

Prospecting in this camp requires the best technical skill, bold and courageous persistence, cool judgment and ample capital. With the knowledge that has been gained regarding the character and modes of occurrence of the ore bodies in this camp, with the present low cost of treatment, and with operations on a sane and business-like basis, the chances for success are vastly greater than in the earlier days.

A production of $34,000,000 in the first decade of a camp's development is a tribute to its substantial worth. While the profits on this ore have not been what might have been wished, the mines have been and are operating at a profit. Had all the ore been treated at the present cost, after allowing for all the past expenditure in development, equipment, fixed charges, &c., the net profit would probably considerably exceed $8,000,000. All these costs have now been lessened, and there are further economies projected to secure the maximum profit on each ton, and to bring lower grade material into the workable class.

METHODS OF MINING.

The first development has usually been surface stripping, tunnelling along the vein, or crosscutting to it. A few of the mines—as the Jumbo and Columbia-Kootenay—are so situated that they have been wholly or largely developed by tunnelling. When the positions of the vein and ore-shoots have been satisfactorily determined, shafts are generally sunk on the dip of the vein. At convenient intervals, formerly about 100 feet, but now usually about 150 feet, stations are cut out and horizontal drifts run along the strike of the vein, following it as closely as possible. The rock is firm and timbering has not often to be resorted to in stations and drives, except occasionally when fissure zones are encountered. The numerous dikes and zones of fracture cause interruptions in, and often displacements of, the vein, so that after passing through them, crosscutting or boring has often to be resorted to in order to locate the vein. Systematic crosscutting and boring are also necessitated by vein branchings, shifting of pay shoots from one set of planes to another, and the possible occurrences of parallel ore-bodies. The extent to which diamond-drilling is utilized is shown by the expenditure by one mine alone of $75,414.68 on this work up to December, 1904. Accurate geological maps of the levels showing the positions of the veins, ore shoots, faults, dikes, &c., are valuable aids in development, indicating as they do, what may be expected on a new level and the direction of displacement, &c. Such maps are kept up and constantly utilized in planning prospective work in most of the larger mines. Raises are put in between levels where needed, as manways or chutes or to prospect the veins or for purposes of ventilation. When an ore shoot is located, a sill-floor is excavated, and, if the shoot is wide, sills and square setts are put in position. The ore is then extracted by overhead stoping, the timbering advancing by successive floors with the stoping, till the level above is reached. If the

shoot is fifteen feet wide or less, stulls are generally used instead of square setts. The ground stands well in most places, timbering being necessary only for convenience in mining, and to prevent the infall of loose blocks and slabs. In some cases—where the ground is not subject to slabbing—only one floor is timbered for tramways and chutes, the stoping above being done from the top of broken down ore, enough being drawn to keep the broken ore a convenient distance below the backs. When stoping is finished, the ore is drawn. The large chambers thus left may afterwards be filled with waste, or used as a store-room for material too low grade for present use. The mine cars are loaded from chutes below the stopes and trammed, usually by hand, to the shaft, where the ore is dumped either into a pocket or directly into a skip. Most of the shafts have three compartments, one for a manway, pipes, electric wires, &c., and two for the skips. The Le Roi main shaft has five compartments, the two additional ones being used for cages for men, timber and cars.

MINING MACHINERY.

The mines are extensively equipped with modern mining machinery. Compressed air is used to operate all the drills and most of the pumps. A brief description of the Le Roi plant will serve for illustration. The Le Roi has two Canadian Rand compressors with a combined capacity of 8,000 cubic feet of free air per minute at sea level, compressed to 95 lbs. gauge pressure. These are operated by steam. The steam plant consists of two Heine safety water-tube boilers set in one battery, and three batteries of three each horizontal return tube steel shell high-pressure boilers. This plant has a nominal capacity of 2,000 horse-power, and is used to operate all the engines about the mine. The hoisting plant consists of two modern, first-motion, winding engines, one of a thousand and the other of five hundred nominal horse-power; the larger consists of two 24" x 60" Corliss engines with two drums 10' in diameter by 5' face, mounted directly on crank shaft. Each drum is equipped with a powerful band friction-clutch, and a strong post brake, operated by steam. It has a special valve gear for hoisting-engine work, and is controlled by link reversing gear, operated by an auxiliary engine. Maximum capacity 14,500 lbs. unbalanced load, raised 2,000 feet per minute with a 100 lb. steam pressure. The drums may be run singly or in counterbalance. Compressed air is used for the signals. The five ton skips, which bring the ore up from the mine, deliver it automatically to crushers, and from these it is delivered to sorting belts (in the Centre Star and Le Roi No. 2 sorting tables are used), from which it falls through the sampler to a storage bin, whence an aerial tram conveys it to a railway bin. The timber for square setts, &c., is framed by mechanical saws. The blacksmith and machine shops are furnished with modern forges, power hammers, lathes, shears, &c. An air-driven, mechanical drill sharpener is operated

a [illegible] The Centre Star uses electric locomotives for handling the ore and waste on the surface, and will probably use them for haulage on the longer levels underground; electricity is used as the motive power for the five cylinder mine pump, which handles most of the mine water. Electricity is used for lighting buildings, stations and mine levels. Telephones connect the mine levels with the surface, and all the mine buildings are connected by telephone. Electricity is also used for a number of mine hoists and air compressors in the camp, and its use is being extended.

PROCESSES OF TREATMENT.

The shipping ore is loaded in 30-ton bottom-dumping railway cars and taken to the smelter. Heretofore, the Le Roi ore has been shipped to the Le Roi smelter at Northport. The Northport plant consists of sampling mill, six rectangular copper furnaces, with blowers, dust chambers and stacks, steam power plant, three Holthoff Wethey calcining furnaces, two briquetting plants, a good roast yard, assay office, water supply, &c.

At present almost all the Rossland ore is treated at the Canadian Smelting Works at Trail.

The Trail smelter is a combination copper-lead plant, with a lead-silver-gold refinery. If, as is planned, a copper converting plant be added, it will be one of the most self-contained copper-lead reduction plants on the continent. In addition to Rossland ores, it treats high grade Boundary, Kamloops, Slocan, Lardeau and East Kootenay ores, together with some small amounts from the adjoining States. Besides ores and concentrates the works can handle mattes, bullion, cyanide and mill products. The refined gold is sold to the United States assay office pending the establishment of a mint in Canada. The greater part of the silver is disposed of in China. The lead, which is an exceptionally pure product, finds a market in Canada, China and Japan, and, to a limited extent, in Australia. Copper sulphate, which is produced as a by-product, is sold in the Northwest provinces. The copper matte is sold to refineries in the United States.

The plant is operated by electricity obtained from Bonnington falls. It consists of copper and lead sampling mills, roast yard, two buildings with hand roasting furnaces, one with six Bruckner roasting cylinders, and one with two double-hearth mechanical roasting furnaces. The blast furnace building contains four rectangular copper furnaces with a capacity of about 1,500 tons of charge; a large furnace, 22 feet by 42 inches, is being added to treat the high grade matte. There are also two lead furnaces and a third one is ordered. There are two briquetting machines, a well equipped blower-room, with motors and an auxiliary Corliss engine, a power and lighting plant, assay laboratory, machine and boiler shops, water supply, electric locomotives for handling the materials, &c. In all, there are

[illegible] buildings [illegible] erected [illegible] belonging to the refinery.

The refinery [illegible] the [illegible] lead refinery [illegible] the [illegible] contains a lead melting room with [illegible] melting pots for the base bullion which is cast into anodes and [illegible] for the refined lead. There is a tank room with 180 tanks in which the lead [illegible] of the anodes is dissolved in an electrolyte [illegible] and lead thus electrolytically deposited on [illegible] sheet of pure lead. This room has a capacity of 51 tons of refined lead per day. The slimes left from the anode go to the silver building where they are melted in a reverberatory furnace to doré bars and then parted with sulphuric acid and the silver is precipitated and cast into bars, 999 fine. The gold left in the parting kettles is melted into bars 995 fine. The solution of copper sulphate resulting from the precipitation of the silver goes to the copper sulphate building where it is crystallized.

The process of copper smelting as conducted in Northport and Trail differs but slightly. In the Trail smelter the present practice is to mix the crude ore with limestone and coke and to smelt to a low grade matte; this is granulated, roasted in the mechanical furnaces and briquetted with 5 per cent of lime as a binder; the briquetted matte, together with certain ores, is re-smelted to a high grade matte, which is shipped to the refineries. For the initial smelt the charge is about 1,500 pounds Rossland ore, 500 pounds limestone and 275 pounds coke. The matte-fall is from 10 to 14 per cent, and the matte contains about:

6 to 8% Cu, 24% S, 50% FeO; the slag runs 42 to 44% SiO_2, [illegible] FeO, 17%, CaO, 15 to 16% Al_2O_3, 0.15 to 0.2 oz. Au., 0.01 to 0.01 [illegible]

For the high grade smelt the charge is 1,000 pounds roasted and briquetted matte, 400 pounds of crude Rossland ore, 300 pounds heap-roasted Rossland ore, and 300 pounds siliceous ore. The matte fall of about 8 per cent gives a matte of about 42 per cent copper and 16 to 20 oz. gold. The slag runs:

50.7% FeO, 38% SiO_2, 4.7% CaO., 0.02 Au., 0.1 Ag. and 0.4 Cu.

This practice was adopted after experiments along the lines followed at Mount Lyell, Tennessee Copper Co., and other points, of concentrating first to a high grade matte, say 20 per cent, and then re-smelting with siliceous ore, low in sulphur and, if possible, high in copper, by this means avoiding the danger of loss in granulation and the costs of roasting and briquetting.

With the Rossland ores, which are so low in copper, high in gold (which prevents running too siliceous a slag), low in sulphur (which is in the form of pyrrhotite), and high in silica and alumina, it was found impracticable to run the low grade matte to a high without roasting, or to produce a high grade matte on the first concentration.

CONCENTRATION.

The problem of concentration has received considerable attention during the last three years, and two mills have been erected in or near the camp.

(a) There is a large amount of ore in and about Rossland that is too low in grade for profitable handling even with the present low costs of smelting, but which, if some cheaper method of extraction of the values were found, would greatly increase the output of the camp and help many properties that, under present conditions, do not promise immediate success. For such ores, concentration has been proposed.

(b) In the operating mines the ore in a stope frequently becomes lower in value or spotty. This poorer material, which is broken down with the good ore and which may be too low grade to send to the smelter, amounts in some cases to a considerable tonnage.

(c) The vein may contain poor material, which, if it could be made to pay costs of extraction, would be mined in the hopes of good grade material being encountered, for, in the same way as good material may suddenly become poor, this poorer material may suddenly become rich, and the mining of such matter would undoubtedly lead to the discovery of good pay shoots. It has been mainly for the purpose of meeting cases (b) and (c) that experiments have been conducted and mills have been built. The processes of concentration experimented with in these mills are water concentration, the Elmore oil process (succeeding a water concentration), and a water concentration followed by cyaniding.

The Le Roi No. 2 mill, which was built in 1903 and which has been in almost continual operation ever since, is a 50 ton mill (42 ton actual). It is operated by a three-phase alternating current. The ore is reduced to first-size by a Blake crusher and then to ½-inch by a Gates crusher which discharges into a storage bin. From this the ore is fed to two Trent (Chilian) mills (one is sufficient to handle the feed) where it is crushed to 30 mesh. From these mills the pulp is led into three Jenckes sizers, the underflow goes to three Wilfley tables, and the overflow from the third sizer to a canvas slime table. There are two No. 4 Wilfley tables and one No. 5; the latter is found to do better work when proper attention is given it. The mill feed is material sorted from the shipping ore at the head-works and some obtained from the dump. It runs about 0·4 or 0·5 per cent of copper. The copper loss is 0·3 per cent, so that with this grade of material the copper loss makes a large percentage. The gold saving is from 56 to 60 per cent, and the copper 20 per cent or thereabouts. From September, 1903, to September, 1904, the mill treated 11,600 tons of ore, producing 523 tons of concentrates running 1·77 oz. gold, 1·14 oz. silver and 1·86 per cent copper. From September, 1904, to September, 1905, according to a published report in the *Engineering and Mining Journal*, the mill treated

10,678 tons of low grade ore (·117 gold, ·306 silver, ·545 copper), saving 424 tons of concentrates averaging 2·542 oz. gold, 2·48 oz silver and 2·613 per cent copper. On material running $5 per ton, taken out in the ordinary process of mining, and consequently with no mining costs to be charged against it, a good profit is said to be made.

In connexion with this mill is a two-unit Elmore oil plant (50 ton), built to handle the tailings from the Wilfly tables (a brief description of an Elmore plant will be given in connexion with the White Bear mill). After a short trial the Elmore plant was closed down, for, while demonstrating the efficiency of the oil process in recovering metallic minerals, the tailings from the Wilfly tables were so low-grade that what could be extracted from them would not pay for operating the oil plant. During its run 4,578 tons of tailings were treated, yielding 137 tons of concentrates containing 1·11 oz. gold, 3·8 oz. silver and 6·42 per cent copper. The final tailings ran about ·076 oz. gold, ·135 oz. silver, and ·206 per cent copper. It has been pointed out by the Canadian Ore Concentration, Ltd., owners of the oil process, that in addition to the low grade of the material to be treated, conditions for economic operating were not present in this mill.

ROSSLAND POWER COMPANY'S MILL.

This is a 200-ton mill, erected on the terrace flat above Trail. The mill was designed to concentrate the ordinary shipping ore of the War Eagle and Centre Star mines. The process was a coarse concentration with jigs, the tailings from which were pulverized in Trent mills, and cyanided. The results were not very satisfactory. The jig concentrates, while clean, contained large amounts of pyrrhotite which does not carry much of the values, and this part of the process did not extract the values expected; to save these, concentrating tables would have to be added. The lowering of the cost of smelting about this time made concentrating ordinary ore unprofitable, so that nothing further has been done with this mill.

WHITE BEAR MILL.

The distinctive features of this 100-ton mill are the crushing of the ore by means of six 5-stamp batteries fitted with 20-mesh screens, sizing to two products, a concentration on six Wilfly tables (three for fines and three for coarse), and the treatment of the tailings, which are pumped from the tailings tank by two centrifugal pumps, in an oil plant. This plant consists of four units; the tailings are led into the mixers, of which there are three, one below the other, in each unit. These mixers are long iron cylinders, with inside baffle plates, which slowly revolve, thoroughly mixing the charge with water and a constant feed of oil from the oil storage tank.

The oil, which has the property of picking up and retaining free gold and metallic sulphides, escapes through a pipe, while the tailings, wormed to the lower end, are discharged into the second mixer below, similarly to the third. The tailings go to two settling tanks, where any oil may float off and be recovered, while the tailings escape through the bottom. The heads (mineral charged oil) and oil from the settling tanks are pumped to a tank (where a steam pipe warms the oil), and dropped into the first oil extractor. This is a centrifugal machine revolving at a high speed, which separates the water and oil from the concentrates, flowing into an oil settling tank from which the oil is returned to the storage tank. The concentrates, both Wilfly and oil are sent to the smelter. The oil mill had been in operation only a short time when the White Bear mine was closed down, and it has not yet resumed operations. While operating, the mill had very low grade feed, but it is claimed, effected a saving of 80 per cent of the values. The oil consumption was about 1½ gallons per ton.

LE ROI MILL.

In the early part of 1905, this 45-ton experimental mill was erected. The process is somewhat hampered by the limited water supply (20 miners' inches under 6-inch head). The ore from the crude ore bin passes over a grizzly, the coarse material through a Blake crusher, and on to the supply bin. An automatic arm feeder loads an elevator discharging into a trommel, which divides the material into four sizes. The first size goes to hydraulic classifiers, the next two, 8 M.M. and 16 M.M. respectively, go to two Hartz jigs, the concentrates go to concentrate bin and the tailings from jigs to a fine set of rolls, from which they go again to the elevator and join the natural process. The fourth size, 26 M.M., goes to a Hartz jig; concentrates to concentrates bin, and tailings from jigs to coarse rolls, from which they go to the elevator and join the natural process. Product discharged from the end of the trommel goes to one Hartz jig, concentrates to bin, tailings of jig to a 7-inch by 10-inch Blake crusher, which discharges them to elevator of the natural process. The hydraulic classifier makes four sizes, which go to four Hartz jigs, concentrates to bins, and tailings of first two jigs to a 5-foot Huntington mill, then to sand pump and to hydraulic classifier; tailings of third and fourth jigs to a 5-foot Huntington mill, which is fitted with fine screens, product to centrifugal pump and then to classifier. The overflow of the classifier is led into V-settling tanks. On account of shortage of water, the clear water of settling tanks is returned to the Hartz jigs. Sediments of settling tanks go to Wilfly tables, that from the first two plugs of the settling tanks to one table, and from the third and fourth to another, and that from the remaining four to a third. The concentrates of the Wilflys go to a drying floor, the tailings to a lower Wilfly table, the

tailings from which go into a tail race. All the overflow waters from concentrate boxes and bins pass through a system of settling tanks. The sediment goes to dry floor, the water back to V-tank and Hartz jigs. All the concentrates are shipped to smelter.

The test-runs for two months gave the following results:—

1st test. 694·9 tons of low grade ore gave 116·116 tons of concentrates, or a concentration ratio of 6 to 1. The smelter returns, which always run higher than the mill samples, equal a saving of 65·5 per cent gold and 51·4 per cent copper, or a total saving of 58·8 per cent.

2nd test. Concentration ratio 4·5 to 1. Saving as per smelter return, gold, 62 per cent; silver, 64·5 per cent; copper, 57·5 per cent, total saving, 60·3 per cent. The tailings run about ·3 per cent copper, or practically the same as the waste rock, without visible mineralization, of the mine. This mill has been closed down, the reason given being that the system of sizing and classifying is faulty.

The experiments in concentration, while not very successful, tend to show that some of the low grade material mined with the shipping ore and sorted from it can be concentrated at a profit, and that with some material it is profitable to sort out the better grade and concentrate the remainder. Those who have experimented are confident that a certain class of the low grade ores can be successfully treated, in a properly designed mill, by water concentration.

The oil process, in the experiments made, has effected a good saving of values, particularly in copper, but, so far, the material which it has had to treat has been too low in grade to pay. The following results of oil tests on Rossland ores have been kindly furnished by Mr. H. H. Claudet, representative in Rossland of the Elmore process:

	Gold.	Silver.	Copper.	Gross Assay value
				$ cts
Feed	09		6	3 60
Wilfly concentrates	72	1 50	2 9	24 00
Wilfly tails and oil plant feed	03	...	5	2 10
Oil concentrates	27	3 50	10 3	48 40
Oil tails	01		2	0 80

NOTE.—About 2½ times as much concentrates produced by the Wilfly as by the oil. Although the tailings the oil plant had to treat ran only $2.10, the oil concentrates were twice as rich as the Wilfly concentrates, produced from $3.60 feed.

	Parts.	Gold.	Copper
Ore	1,000	57	·91
Concentrates—water	42	11·0	4 5
Concentrates—oil	84	7	4
Tailings	964	·095	1
Loss	110		
Recovery		87 3%	91·6%

Ratio of concentration 8 1 ; ground to 60 mesh

SIZING TEST.

	Sizing Test.		Gold.	Copper.
Left on 20 mesh screen	45 4	assay value	41	65
" 30 "	11 5	"	73	83
" 60 "	18 7	"	32	88
Finer than 60 "	24 4	"	·59	1 52
Slimes	9·5	"	·17	1 27

Average result of water and oil concentration on seven samples, in 16 different tests made, samples crushed to 30 or 60 mesh.

	Gold.	Copper.	Gross Assay value
			$ cts
Average assay of seven different samples	·278	1 0	8 56
Average assay of tailings of 16 different tests on these samples	·06	·25	
Ratio of concentration 10:1 ; extraction	·81	·78	
Average of se[illegible] tailings of best tests	·044 oz.	·2	

Some of th[illegible]culties in the way of greater success in concentration are:—The low value of the material to be treated, (from what is now shipping grade the values drop suddenly to about $5 per ton, and very little material of intermediate grade has been found); the wide difference in the nature of the low grade material of the camp and even of the same mine; and the values distributed through the rock are in a finely divided state. Some of the low grade material is siliceous and therefore amenable to water and oil concentration. It appears probable that in the deeper workings siliceous ore may be more abundant, and water and perhaps oil concentration may become more important. But much of the low grade material is

highly ferruginous (pyrrhotite, &c., 40 to 80 per cent). With such material the ratio of concentration by gravity methods or oil must be too small to make it a practical treatment. For this material pyritic smelting, and the "Hendry" electrocyanide process has been suggested. The pyrrhotite as a rule contans very little gold. Mr. P. S. Couldrey, manager of the Le Roi No. 2 mine, obtained the following results in an experiment on typical ore. The sample assayed 12 oz. in gold and 4·80 per cent copper. Crushed to 50 mesh and separated by a magnet, the magnetic portion, pyrrhotite, contained 5·9 oz. gold and 2 per cent copper, the non-magnetic portion (chalcopyrite) contained 34 oz. gold and 10·6 per cent copper, or for every pound of copper there were 34·212 oz. of gold. If the gold in the pyrrhotite was held by the copper and was present in the same ratio, the 40 pounds of copper in the ton of pyrrhotite would contain 6·15 oz. of gold, which is almost the amount actually held (5·9 oz.). So that it appears probably that what gold is found in pyrrhotite is held by the copper also present.

In a number of cases, assays of pyrrhotite showed little or no gold or copper to be therein.

In the above experiment, of the 34 oz. of gold in the chalcopyrite, 13 oz. are free, or recoverable by amalgamation. In one series of mill tests 11·4 per cent of the gold contents were caught in amalgamation plates. It is stated by one mill superintendent that while 12½ per cent of the gold is free, the plates corrode too fast for successful amalgamation. In some tests by amalgamation in a mortar as much as 50 per cent of the gold was recovered. In a microscopic examination of 50 mesh pulp, a small flake of gold was detected, also a few scales of a white silvery mineral that is probably bismuthinite or tellurides, but these were too small to collect or to analyse. The metallic minerals as far as could be seen, seemed to be freed entirely from rock matter, and none of the grains of the silicate minerals or rock matter showed any adhering particles of metallic minerals. From this it would seem that not all the values left in the tailings are locked up in the silicate grains, in the form of sulphides, or if so they must be in an extremely fine state of division.

When gold and copper values in the pyrrhotite are low, magnetic separation in water, or some other form of magnetic separation might perhaps be feasible.

COST OF MINING AND TREATMENT.

The costs of mining and treatment in the early days rendered $40 ore barely profitable. With the improvements in the roads, $25 became the limit. With the advent of railways and local smelters costs were still further reduced and there has been an almost continual decline till the present. Costs of supplies are now about 15 per cent to 20 per cent less than in 1897. Wages have remained stationary. In 1899, an eight-hour day for workers underground was

instituted, which it is claimed added to the cost of mining. In the case of the Le Roi it was estimated by Mr. R. E. Parmer to add 72 cents to the costs per ton of the ore produced, but in spite of this, costs of mining are now much lower. It is, however, in smelting that the reduction in costs has been most marked. In 1897 the Le Roi was shipping to Trail on a contract which called for 75,000 tons of ore, at a rate for freight and treatment of $11 per ton, direct, or $16 direct and indirect charges. In 1897 the Northport smelter was built, the Le Roi Company owning a three-quarter interest in it. According to agreement between the mine and the smelter (1), the smelter was to treat the Le Roi ore for a period of five years at a direct rate of $8.75 per ton, or about $13.75 direct and indirect charges (the Le Roi Company owning three-quarters of the smelter received three-quarters of the profits). In 1900 the Le Roi Company bought out the remaining one-quarter interest in the smelter and the contract. In 1897 the War Eagle's smelting rate was $9.96 direct or $14.29 direct and indirect charges. During the past year the direct and indirect charges on the shipping ore of the camp was about $6. The direct charges for freight and treatment are now from about $3.25 to $4 per ton, according to the character of the ore. The following table of costs, compiled from the published reports of the mines, and from the paper referred to below (2) illustrates some of the reductions in costs.

In quoting the costs from the published reports of the companies, ore from development work, dumps, or ore already stoped, is not included, as the amounts vary from year to year and would not afford a basis for comparison. The lowering of indirect smelting costs is not altogether due to the lower grade of ore; the scale of deductions has been greatly lowered.

	*Le Roi.			War Eagle.				Centre Star.		
	1897.	1899.	1904 5	1897.	1899.	1904.	1905.	1900.	1904.	1905
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Mining	....	5 55	2 78	3 24	3 92	2 54	..	3 59	2 31	....
Development	....	....	0 90	10 67	1 74	0 76	...	6 73	0 74	....
Smelting direct	11 00	8 75	5 88	9 96	4 91	4 46	6 12	6 00	4 09	5 89
Smelting indirect	5 00	5 00		4 33	6 25	2 60		3 57	1 72	
Raising	....	....	27 58	30 33	36 81	28 08	...	56 01	38 60	...
Winzing	....	....	48 96	..	44 42	36 15	....	59 01	. .	..
Drifting	....	....	14 80	20 11	23 81	17 7[illegible]	....	26 82	18 19	.
Diamond drilling	....	....	2 98	....	....	....	....	....	....	....

*Le Roi costs for 1897 and 1899 taken from paper of Bernard Macdonald, already referred to.

(1) and (2). Hoisting and Haulage in Mining Operations, by Bernard Macdonald. Journal Canadiar Mining Institute 1902, page 311.

ORE EXTRACTION—COST PER TON.

—	1897.	1899.	1901.	1902.	1903.	1904.
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Drilling	0 94	1 53	0 43	0 73	0 64	0 46
Blasting	....	...	0 04	0 06	0 05	0 05
Explosives	0 27	0 25	0 13	0 26	0 22	0 16
General mine supplies	0 14¼	0 06	0 08	0 10	0 05	0 04
Mine lighting, candles	0 03	0 03	0 02	0 02	0 02	0 02
Mine lighting, electric	...	0 03	0 03	0 03	0 02	0 02
Smithing	0 10¼	0 15	0 07	0 14	0 08	0 04
Tramming and shovelling, direct	0 44½	....	0 28	0 29	0 27	0 28
Tramming and shovelling, apportioned		0 53	0 11	0 12	0 14	0 12
Timbering, labour	0 31½	....	0 18	0 28	0 25	0 29
Timbering material	....	0 29	0 11	0 15	0 14	0 12
Machine drill, fitting and repairs	0 23¼	0 05	0 07	0 14	0 07	0 08
General mine labour	......	0 30	0 28	0 22	0 16	0 13
Hoisting, underground	....	..		...	...	0 01
Hoisting shaft	0 18	0 13	0 23	0 16	0 23	0 24
Compressed air	....	0 21	0 09	0 15	0 18	0 11
Ventilation	0 07	....	0 06	0 03	0 02	0 09
Assaying	......	0 05	0 07	0 05	0 05	0 05
Surveying	0 26½	0 02	0 04	0 02	0 02	0 02
General	0 25¼	0 31	0 49	0 25	0 28	0 27
	3 24½	3 94	2 81	3 20	2 90	2 53
Stoping figured on tons	....	45,810	17,910	20,327	58,683	53,084

The mine from which these costs were taken was under the same management for the whole period, except during 1897.

The total costs, including all expenses connected with mining, smelting, depreciation, &c., is now probably ... $10 per ton. Ore running about $7.50 against which general ... similar expenses have not to be charged can be profitably handled.

PROFITS.

The net profits on the operations of the leading mines for the last financial year, according to published statements, should be about $775,000. There have been paid in dividends to the end of 1903, $2,377,050. The Le Roi No. 2 has since paid several substantial dividends, £18,900 in 1904 and £25,200 in 1905, and the other mines have creditable cash balances.

While the amount paid in dividends is not large in comparison to the value of the ore produced, it is to be remembered, that the mines started with little or no working capital, and that the extensive development, the expense of machinery and plants, had to be met by profits from the ore extracted. Until recently, smelting

costs have been heavy. The costs of development, especially in the early days when less was known regarding the occurrence of ore, the effects of faulting and diking, were high. In the case of one mine, these costs have been $1.58 per ton of ore exposed, and in a second, $2.60. The present costs for development, per ton of ore, are much less. The following extract from a General Manager's report is quoted in Bulletin 19, Bureau of Information, British Columbia, 'The whole of our plant, surface improvement and buildings, both at the mine and smelter, representing an expenditure of over $1,000,000 and in addition, the mine itself on which there has been spent, apart altogether from the purchase price, a sum of $500,000, is absolutely free and unencumbered. As working capital was not provided, the $1,500,000 represents profits on ore extracted. Until the mines had paid for these improvements, interest as well, had to be met out of profits.' This hand to mouth existence of the mines has affected the profits in another direction, through the lack of extensive development work, ahead of mining. The Rossland ores have kept two smelters in operation. With a smelter dependent on one mine, or holding a contract for a certain tonnage from a mine, when, as happens, a number of the working faces suddenly became poor, the mine has had to ship material below grade in order to keep up the tonnage demanded. The Le Roi No. 2, which for the last few years has shipped only carefully selected ore, has maintained regular dividends, although the tonnage produced has been small. At present the mines give promise of adding materially to their record of dividends.

NOTE.—Since the above was written the Le Roi has declared a dividend of about $75,000, and the Consolidated Mining and Smelting Company, which includes the Centre Star and War Eagle mines and the Trail smelter, as well as the St. Eugene mine, has declared a quarterly dividend of 2½%, amounting to $117,000.